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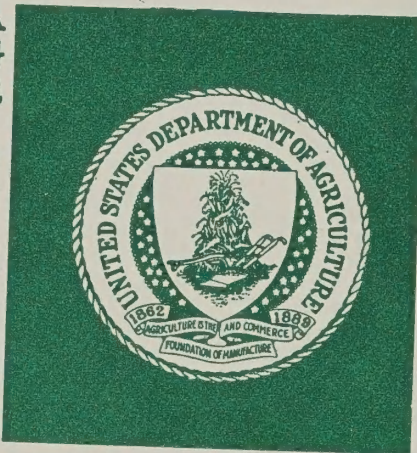
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RESEARCH PROGRESS REPORT

AGRICULTURAL RESEARCH, P.L. 85-934 and P.L. 89-106

1. GRANT NO.

12-14-100-11438(75)

2. REPORT NO.

5403

3. PROJECT NO.

1831

4. FROM (Name and address of grantee)

Department of Soil & Crop Sciences
Texas Agricultural Experiment Station
Texas A&M University

5. REPORT PERIOD

(Should coincide with Fiscal Report requirements)

FROM

Jan 1, 1974

TO

June 30, 1974

PROJECT TITLE

Investigations on the functional properties of defatted sunflower meal for use in food products.

7. SIGNIFICANT FINDINGS

The optimum emulsion capacity of whole sunflower meal was established at pH 7. Water absorption of the meal is an important varietal attribute. Optimum production of a stable foam was found to occur at pH 9 and 8% meal concentration. Sucrose and potassium bitartrate are adjuncts to stability and volume.

8. SUMMARY OF PROGRESS (Give concise summary of progress for this report period.)

(If additional space is required, use ARS FORM 52A)

Terminal Report

In order to investigate functional versatility of sunflower meal, testing of whole and defatted sunflower meal was carried out covering a wide range of functional properties. The tests included hydration, emulsification and stabilization, water absorption and retention, fat absorption and retention, viscosity, dough formation, gel formation, adhesion, cohesion, and aeration or whipping properties.

Whole Meal

After completion of preliminary functionality tests, the areas of whippability and emulsion capacity and stability were chosen for further study. The utilization of whole meal was studied on a comparative basis with defatted meal.

Whippability. Whole meal exhibited poor whipping properties; especially when compared with defatted meal. In searching for the cause of this low level of functionality, the work with eggs by Zabik and Brown (1) and Jeslin and Proctor (2) was enlightening. It appears to be conclusive that poor foaming is associated with free fat. The whole, non-defatted, meal contained 55.5% oil. A large portion of this lipid material appeared in the form of an oily film on the surface of the dry particles. This acted as a barrier to foam formation upon whipping. When the meal contains 10% or less fat, a voluminous and stable foam can easily be formed.

Emulsion. The emulsion capacity of whole meal is limited. The whole meal has only one-third the emulsifying capacity of defatted meal.

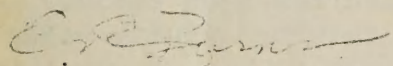
Defatted Meal

The functional properties of defatted sunflower meal were delineated and compared with defatted soy meal. Whippability, emulsion properties and water binding are the most promising functional attributes.

Emulsion stability. Factors affecting the stability of emulsions made by mixing defatted sunflower meal with oil and water were studied. Using percent oil separation as an index, stability was increased by 30% when mixing speed was increased from 800 rpm to 1200 rpm. Increasing the holding temperature of

(continued)

9. SIGNATURE OF PRINCIPAL INVESTIGATOR IN CHARGE



10. DIRECTOR OF RESEARCH INSTITUTION

Original signed by

Jarvis E. Miller

Director U. S. DEPT. OF AGRICULTURE

ARS FORM 52
OCT. 1968

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SUMMARY OF PROGRESS (Continued)

the emulsion from 70°C to 85°C caused a 24% decrease in stability. This is probably due to partial denaturation of the protein causing altered membrane formation around the fat globules (3).

Emulsion capacity. Capacity of the meal to emulsify oil was increased when the pH was increased from 5.5 to 8.0. The influence would be the increased solubility of protein at pH values higher than 5.5 (4). Only the soluble protein fraction has been suggested to act as an effective emulsifying agent (5). A temperature decrease from 25°C to 15°C during mixing caused a 20% increase in capacity; increased surface tension of the oil droplets is responsible for this effect. At a mixing speed of 1100 rpm, the amount of emulsified oil increased by 16% as the rate of oil addition increased from 0.6 ml/sec to 1.2 ml/sec. At such a rate, protein membranes were believed to approach instantaneous formation around the oil droplets. Vigorous mixing assured adequate dispersion of oil and intermixing of components.

Decreasing the mixing speed during emulsification increased the emulsion capacity of sunflower meal. Comparison testing between soybean meal and sunflower meal indicated that the emulsion capacity of sunflower meal exceeds that of soy by an average of 63.2%. High heat treatments (160°F to 180°F) decreased the emulsion capacity of soybean and sunflower by 48 and 10% respectively. It appears that a substantial amount of protein is denatured in this heat range.

Water adsorption. The water adsorption properties of defatted meal from five sunflower cultivars and a similarly prepared soybean meal were determined at relative humidities ranging from 30 to 95% and temperatures of 5°C and 25°C. Varietal differences were found over the humidity and temperature ranges. The total sugar content was poorly correlated with the adsorption pattern suggested by Kilara et al. (6). The various protein contents of the cultivars would be a logical explanation for differences in water adsorption. The more hygroscopic components of the meal, principally salt and protein, are thought to account for the water binding properties (7). High heat treatment (160°-180°F) of the defatted meal decreased water adsorption by 9.5-11.5% as the relative humidity was increased.

Bakery products. Enrichment of bakery products with sunflower meal and moisture retention was studied. Cupcakes and cookies were chosen since moisture is an important factor in the flavor, texture and keeping quality of the finished product. These bakery items are also adapted to quality controlled production and subjective and objective evaluation.

Cupcakes were prepared using a basic white cake formula and a standard one-bowl method. The mixture was enriched with defatted sunflower meal at 0, 1, 3, 5, 7, 10, 15 and 25% levels of substitution in the flour content. Increases in percent protein over the control ranged from 2.14 at the 1% enrichment level to 53.59 at the 25% enrichment level. The cupcakes were evaluated for color, texture, flavor, volume and yield. The addition of defatted sunflower meal to the cupcakes provided a more nutritious product without decreased yield or acceptability.

Cookies prepared from a standard drop cookie formulation were enriched with defatted sunflower meal at 5, 15 and 30% levels. The maximum increase in protein content was 54.1%. The viscosity of cookie batters enriched at the 0, 5, 15 and 30% levels were measured using a Brookfield Viscometer. The batter became progressively thicker as the amount of sunflower meal increased.

Cookies were evaluated objectively for moisture and also texture in terms of shear values measured by the Allo-Kramer shear press. (continued)

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A trained taste panel scored the cookies for color, texture, flavor, appearance and overall acceptance. A portion of the cookies were stored for 24 and 72 hours at 45°F, 70°F (ambient temperature), and 130°F.

The addition of sunflower meal did not alter moisture retention or shelf life. The shear values were affected only at the 130°F storage temperature. The cookies became hard and brittle, which was attributed to desiccation. This caused the shear values to be elevated.

As the level of sunflower meal increased, cookie color changed from off-white to yellow-green. The color was objectionable to the taste panel only at the 30% level. The taste panel indicated a definite preference for cookies enriched at the 5% level. These cookies were scored significantly higher in flavor, texture and product acceptance. Appearance was rated acceptable at all levels, except the 30% level.

Whippability. Sunflower meal foams were prepared by dispersing 3 g of meal into 100 ml of aqueous buffer solution and whipping for five minutes in a Sunbeam Mixmaster at a speed of 9 on the calibration scale. Soybean meal foams were prepared in the same manner. At pH 7, sunflower foams increased in volume 350% while soybean increased only 40%.

Whipping time. The volume increased markedly up to twelve minutes, then began a slow decline. Foam stability gradually approached a maximum between 7 and 10 minutes, then decreased slowly with continued whipping. Sunflower meal foams would not be subject to degradation due to overbeating in a commercial operation.

Additives. Commercial foaming products usually contain salts, flavoring, sugar and other additives (9). In many preparations, however, only sugar is added. Additives chosen for investigation were sucrose, NaCl, sodium phosphate, potassium hexametaphosphate and potassium bitartrate.

The addition of sucrose caused a decrease in volume but increased stability at 30 minutes standing time. Stability decreased slightly after standing 2 hours at room temperature. The addition of 5% NaCl caused a marked increase in foam volume, but had little effect on stability. Very little effect was noted when either of the phosphates was added. Potassium bitartrate effected a color change from green to white. This was due to a lowering of pH from 9 to 5. Also noted was a drastic reduction in volume and a marked decrease in stability. However, when sucrose was added with potassium bitartrate, foam volume was increased and the foam became extremely stable.

The optimum pH, temperature and meal concentration for production of voluminous, stable, fine-textured foams was pinpointed by statistical treatment of the data involving Response Surface Methodology (10). Optimum conditions were pH 9.00, 8% meal concentration and 15°C. Using these optimum conditions as a basis, investigations were then carried out to determine individual effects on sunflower meal foams of pH, temperature, meal concentration, whipping time and additives. The additives chosen were sucrose, sodium chloride, sodium phosphate tribasic, sodium hexametaphosphate and potassium bitartrate.

pH. The desired foam volume increase was obtained below pH 4 and above pH 8. The poorest foams were obtained in the isoelectric region for sunflower protein, near pH 5. This lends credence to the theory that a protein must be soluble in order to foam (8, 9). Stable foams were obtained above pH 8.

Temperature. Temperature had a definite effect on foam volume. Reduction in volume is pronounced at 55°C and, above 65°C, the reduction becomes serious. This is evidently due to denaturation of protein and concurrent (continued)

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loss of solubility (11). Temperature had very little effect upon foam stability. Meal concentration. Low meal concentrations produced foams with poor volume and very poor stability. As the concentration was increased, foam volume increased and foam stability improved. 8% concentration produced the greatest foam volume with acceptable stability. Above 8%, the volume declined.

Summary

Optimum emulsion capacity is at pH 7. Lower speed of mixing and fast rate of oil addition increase emulsion capacity. There are varietal differences in the water adsorption capacity of sunflower meals. This is attributed to varying protein concentrations. Optimum foam production and foam stability are achieved at pH 9, meal concentration 8%, temperature 15°C and a whipping time of 12 minutes. The addition of sucrose and potassium bitartrate to the foam during whipping produces a bright white foam with good volume and excellent stability.

Sunflower meal has potential for incorporation into human food products as an excellent source of protein enrichment and as a functional agent in foods designed for sophisticated markets. The functionality excels soybean in several areas. The most promising areas: emulsion capacity, water adsorption and retention and aeration properties, were examined in this study.

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